ADA5 - Coursework for Academic year 2023-2024

Advanced Dynamics and Applications 5 (ADA5)

As par of the assessment of Advanced Dynamics and Applications (ADA5) course you are required to conduct a coursework which holds 40% of the total grade of the course consisting in two parts: **Part I - Technical review report (20%)** and **Part II – Technical simulation report (20%)**. The coursework should be conducted in groups of 3 students each. The groups are decided by the students. The list of members of each group along with the topic chosen for the Part I of the assessment should be emailed to David García Cava via email david.garcia@ed.ac.uk and Francisca Martínez Hergueta via email francisca.mhergueta@ed.ac.uk by the end of week 2 - Friday, 26^{th} January 2024.

The deadline of the coursework is by Tuesday, 19^{th} March 2024 at 16:00.
For your submission, you might combine Part I and Part II in a single file.

Part I - Technical review report (20%)

This part consists on conducting a technical review of the topic selected by means of understanding of the publications shared with the group. All topics are related through the content of the course. A book chapter will be also provided to support the Topic (Journal paper) on the Environmental and operational variabilites (EOV). If your topic will not directly address the problem of EOV, you should reflect on how a EOV mitigation technique could be applied in the context of your journal paper. The *technical review report* is limited to **5-pages** with an extra page for the list of references.

The aim of the proposed report is to provide a thorough review of a particular vibration-based analysis/methodology, such that an engineer interested in the technique can understand the basis of the research question addressed, methodology, experiment, technical aspects, and the challenges associated with the topic. More in detail the technical review report should implicitly answer the following questions:

- What is the research statement of the work?
- How the content of ADA5, both theoretical and descriptive (methodologically) can be related to the work?
- How the theoretical fundamentals have facilitated the outcomes of the work?
- Identify and reflect on the innovations proposed in the work?
- How the work can be extrapolated to other fields or studies?

Topics has been introduced in week 1 and they can be found also in the Learn page of the course. Each student group should select a topic sending an email with all the group components to David García Cava via eamil david.garcia@ed.ac.uk and Francisca Martínez Hergueta via email francisca.mhergueta@ed.ac.uk. Topics will be assigned in a first comes first serves basis, and the list of taken projects will be published in the board. The material for the report will be provided (1 scientific publication and book chapter per group). A *voluntary* feedback session will be hold during the tutorial of week 5. Each group could make a poster about the Part I (only) of their topics addressing the requirements for the coursework. Formative feedback will be provided.

You are advised to use the following structure for your technical review report; however, adherence to this structure is not mandatory.

- **Abstract.**
  Your abstract should be between 100-150 words. It should summarise the main aim of the report given an indication of the research question addressed, methodology and main general findings.

- **Introduction and motivation.**
  This includes the introduction, background section and problem statement. The introductory sections set the scene. They do this by providing some basic background information and introducing the research question that your report will be addressing. You should focus on explaining why this question is important. A final paragraph in the introduction setting out the structure of the paper is also helpful.

- **Theoretical fundamentals and Methodology.**
  Describe and define the theoretical fundamentals on what the work has been set. Try to bring the content learnt during the course for a comprehensive reflection. What are the approaches conducted? What are the main assumptions? How the methodology has been defined and what are the contributions of each step on the global study?

- **Experimental and/or validation of the work.**
  How the experimental campaign has been defined and what assumptions have been made to facilitate the experiment and validation of the work. Which instrumentation has been used? How the data has been acquired? Also, how would you have complemented the study to provide a more comprehensive study?

- **Discussion and Innovations.**
  What are the innovations presented in the work? How the work has built up on the fundamentals to address the research statement under consideration?

- **Conclusions and limitations.**
  The conclusions section should summarise the most important points of your technical report. Also reflect on the main impact of the work and how this can be extrapolated to further analysis, applications. You should also be able to identify the limitations of the work and what could be a changed to overtake the challenges that this work has aroused.

- **References**
  You should include the full citation to referenced documents using a recognised referencing system (e.g. Harvard, Vancouver ...). A recommended number of 10 references is appropriated for this report.

Part II - Technical simulation report (20%)

A platform is supported by a cantilever beam as illustrated in the Figure 1. The owner of the installation has concerns due to the potential deterioration of the beam because it is exposed to severe operational conditions and thus prone to failure. The owner is looking for engineering experts in the field of structural dynamics as they are looking for installing a vibration-based system to evaluate potential deterioration of the structural element. The structure is intended to be instrumented with three accelerometers equally distributed along the span of the beam (see Figure 1) to measure in the longitudinal direction. The structural manager of the company has listed the requirements for this project and are described as follows:

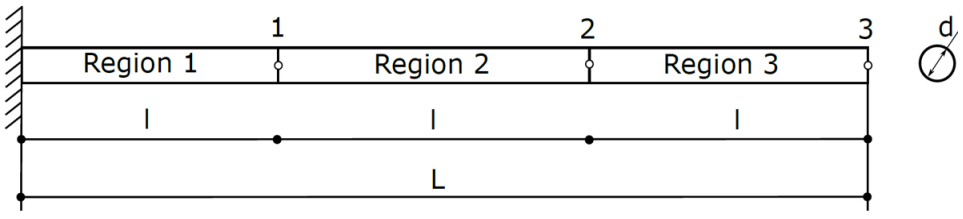

Figure 1: Graphical representation of the structure.

Specifications:
Diameter: d=30cm
Length: L=5m
Material steel
Elastic modulus: E= 200 GPa
Density: ρ= 7800 kg/m^3

A technical simulation report should have been asked by the company with maximum **5-pages** and it should contain the following points:

1. Construct the free body diagram and derive the corresponding equation of motion for every degree-of-freedom.

2. Calculate natural frequencies (in Hz) and mode shapes of the structure. (Please normalise the mode shapes with respect to the element with the maximum absolute value).

3. Assume proportional damping in the form $\mathbf{C} = a\mathbf{M} + b\mathbf{K}$ with $a = 1 \times 10^{-5}$ and $b = 1 \times 10^{-2}$. Calculate the modal damping ratios of the structure.

4. Calculate the Frequency Response Runction (FRF) of each degree of freedom in respect to the excitation point at 3 as 1 unit.

5. Use amplitude graphs of the FRFs and the half power method in order to calculate the natural frequencies, the damping ratios and mode shapes. Compare with those obtained in step 2.

6. Now, model the system in the state-space form and using Runge Kutta or matrix exponential method solve it numerically to obtain the structural displacements, velocities and accelerations for a random excitation at all the degree of freedom.

7. Calculate the Power Spectral Densities of the responses at each degree of freedom using Welch estimator.

8. Using the model in 6, assume the system to be output-only and apply Stochastic Subspace Identification to the system considering all the degree of freedom and estimate A and C matrices. Estimate the modal parameters (natural frequencies, damping ratios and mode shapes) and comment in the assumptions/parameters selected. Then, compare with ones estimated in step 2 a 5.

The structure is sometimes exposed to 100 Celsius due to its operation, which reduces the Elastic Modulus of the steel to $190GPa$.

9. Please recalculate the modal parameters in the step 2 and the FRF in the step 4. As well as the estimation of the modal parameters estimated as in the step 8.

10. Discuss and evaluate the consequences when comparing before and after the extreme temperature change.